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KVANE - A KVANEFJELD DRILL CORE DATABASE

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Abstract. A database KVANE containing all drill core information from the drilling programme carried out in 1958, 1962, 1969 and 1977 at the uranium deposit in Kvanefjeld, Southwest Greenland has been made. The application software "Statistical Analysis System (SAS)" was used as the programming tool. It is shown how this software, usually used for other purposes, satisfy a demand of easy storing of larger data amounts. The paper describes how KVANE was made and organized and how data can be picked out of the database. A short introduction to the SAS system is also given.

The database has been implemented at the Northern European University Computing Center (NEUCC) at the Technical University of Denmark.

INIS descriptors: DATA ACQUISITION SYSTEMS, DRILL CORES, GEOLOGIC DEPOSITS, GREENLAND, INFORMATION SYSTEMS, URANIUM ORES.

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INTRODUCTION

In connection with a geostatistical evaluation of the uranium-mineralization at Kvanefjeld within the Ilímaussaq intrusion in South Greenland, it was decided to establish a database containing all analytical information from the drilling programmes carried out in the years 1958 (Bondam, 1958), 1962, 1969 (Nielsen, 1969 and 1970) and 1977 (Nyegaard et al., 1977). The result of all the diamond drilling programmes were 70 holes with a total core length of approximately 10460 meters (fig. 1). Among these holes only a few are inclined with various dips while the rest are vertical. Each sample represents a one meter section. Drill cores from the drillings in 1958, 1962 and 1969 were sampled for every one meter while only every second meter of the drill core obtained in 1977 was analysed. The total number of drill core samples was 5663.

All 5663 samples were analysed for U, Th and K by gamma-ray spectrometry (GAM-SPEC). On the 1958 and 1969 samples a drill core scanning procedure was used (Løvborg et al., 1972) while all analytical work on the 1977 samples was done on crushed coresplits.

In addition to the gamma-ray spectrometry, an extensive analytical programme was carried out on the 1977 samples by various laboratories. This analytical programme involved the use of X-ray fluorescence (XRF), energy dispersive X-ray fluorescence using different radioactive sources (EDX-CD and EDX-PLU), optical spectrometry for Li and Be (OP-SPEC), fluorine-specific ion-electrode (F) and instrumental neutron activation analysis (ENAA). A summary discription of this work is given by Nyegaard (1979). Table 1 shows which analytical methods were used for each element. The table also includes the number of analyses, number of drill holes and a method index which will be explained later.

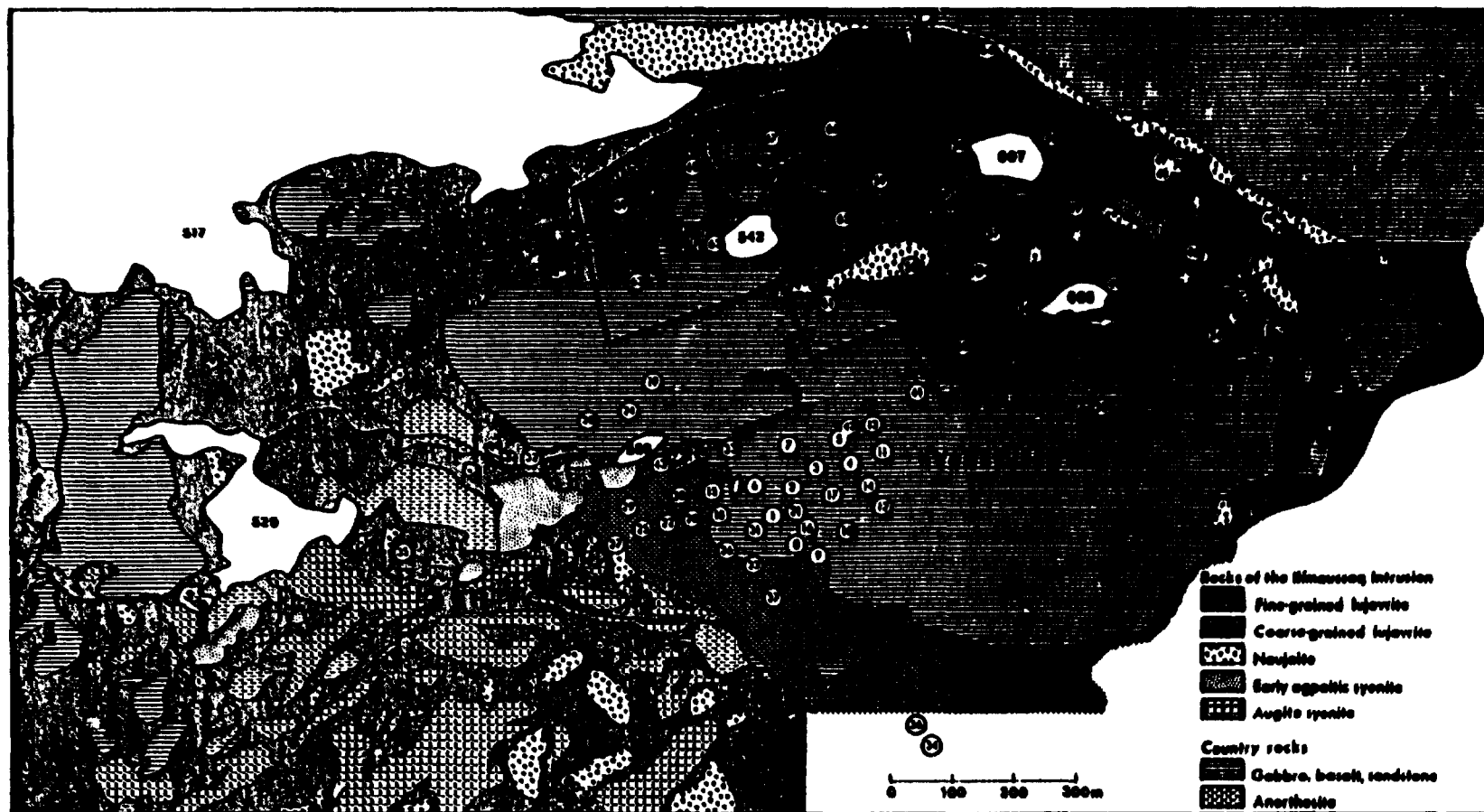


Figure 1. Position of drill holes in the Kvanefjeld area. The drill holes located in the area outlined by the solid line, was, except for holes 29 and 40, drilled in 1977. (From Nyegaard, 1979).

Table 1. Summary table showing the analytical work on drill core samples.

Abbreviations used for analytical method and the Method Index are explained in the text. N_{cores} is the number of cores involved while N_{samples} is the number of samples which was analysed by the method concerned.

‡): Unreliable elements have been rejected.

Analytical Method	Elements obtained	N samples	Method Index	N cores
GAM-SPEC	U,Th,‡	5663	1	63
XRF	Zn,Ga,Rb,Sr,Y,Zr,Nb,Pb,Th	614	2	7
EDX-CD	Fe,Rb,Sr,Y,Zr,Nb,Mo,Pb,Th,U	234	3	18
F	F	570	4	23
OP-SPEC	Li,Be	107	5	13
ENAA ‡)	Na,K,Sc,Cr,Mn,Fe,Co,Zn,Rb,Zr, Sn,Sb,Cs,Ba,La,Ce,Nd,Sm,Eu, Gd,Tb,Yb,Lu,Hf,Ta,Th	833	6	13
EDX-PLU ‡)	K,Ca,Ti,Mn,Fe,Ni,Cu,Zn,Ga,Pb, Sr	573	7	7

THE SAS SYSTEM

The database KVANE was installed in an IBM 3033 computer at the Northern European University Computing Center (NEUCC) at the Technical University of Denmark. Since IBM computers in general are not particularly database-oriented, a need for an alternative database-software arose. The Statistical Analysis System (SAS) was found to satisfy this demand, especially from the user's point of view. SAS is a software-package which is

normally used for statistical purposes (Barr et al., 1976). SAS works independently of other software systems because it has its own PLI-like programming language for data manipulation. The fundamental feature of the SAS system is the creation of a SAS data set, i.e. the database, on which further statistical work can be done. A SAS data set can be compared to a two-dimensional matrix where each row represents one observation (e.g. one sample), and each column one variable e.g. an analytical value, an alphanumeric identifier, etc.). In figure 2 an example of a SAS data set is shown. The variable OBS (observation no.) is created by SAS.

OBS	SAMPLE	URANIUM	THORIUM	DEPTH	GEOLOGY
1	234411	145.1	327.8	17.2	332
2	234412	167.9	456.2	18.4	118
3	234413	258.0	362.9	19.1	118
4	234414	144.4	532.7	20.3	333

Figure 2. SAS data set with dummy values. The data set contains 5 real variables and an internal variable OBS and has four observations.

The SAS-language, which includes the most common programming options as IF THEN, GO TO and assignment statements, is normally used on the stage where the SAS database is made. It differs from other languages like FORTRAN and ALGOL because DO-loops are implied. This means that the statement

RATIO = TH/U;

will result in creation of a new variable RATIO with the value

Value contained in the variable TH
Value contained in the variable U

for each observation.

Among the programming options command-like instructions as MERGE and UPDATE appear. These are of special interest in the present case, since they allow the user to add new variables (columns) and observations (rows) respectively to an existing SAS data set. When a SAS data set is ready, more advanced calculations can easily be carried out using the SAS procedures. SAS procedures allow the user to print, sort, plot and statistically analyse the data. An impression of how easy SAS works is given by the following example. Let's say we want a print-out of an existing SAS data set. The statement

```
PROC PRINT; DATA=KVANE;
```

will give the whole content of the data set KVANE well - formatted and with headings on each column. It should be noted, that the boring job of writing output-formats has been eliminated, since SAS itself takes care of that.

On the IBM 3033 computer at NEUCC SAS can either be used in batchjobs or interactively under TSO (Time Sharing Option). SAS data sets are always used temporary but can also be stored in a permanent file e.g. on disk or magnetic tape. A SAS file is only to be read by SAS itself. The file contains in addition to the data set a directory with variable names, variable length etc.

If processing is to be carried out on the data with other type of programmes (e.g. a plotting routine written in FORTRAN or on other computers without the SAS system, the user must at first transfer data from the SAS file to a formatted file (e.g. data sets, card images). This is easily by the PUT-command. SAS is therefore to be considered a rather system dependent database.

Finally the handling of missing values in SAS should be mentioned. When 'holes' in the data matrix exist, SAS represents these by a decimal point. Thus the decimal point is the value of a certain variable (not zero) and could be used directly. The statement

IF ZIRCON = . ;

finds all observations in the data set where an analytical value of variable ZIRCON exists.

CREATION OF THE KVANE DATABASE

As shown in table 1 analytical results were obtained using up to seven different types of analytical procedures. Each analytical result was supplied on punched cards or on card images stored on magnetic tape. This data material together with start coordinates for the 70 drill cores were placed in eight different card files, comprising the input material for SAS. Since the analytical work was carried out in different laboratories there was neither consistency in the data nor in the way the data were presented (notation and format) nor in the way of identifying a sample. It was therefore necessary to read the eight data files separately and create eight different SAS data sets simultaneously. Later on these data sets were merged together to make up the database KVANE (fig. 3). Each sample was labelled with a sample number which in notation lies close to those supplied by the laboratories. The notation used in KVANE is defined by a numeric variable

PR_NR = DDMMM.CC

where DD is the drill hole number and MMM.CC is the distance from the top of the drill hole to the point on the core where the sample starts (meter system). A sample taken from 37.15 meters to 38.15 meters in drill hole 7 has accordingly the value 7037.15 assigned to the variable PR_NR.

In each of the eight input programmes an error facility was built in. The necessity of this was clearly demonstrated when

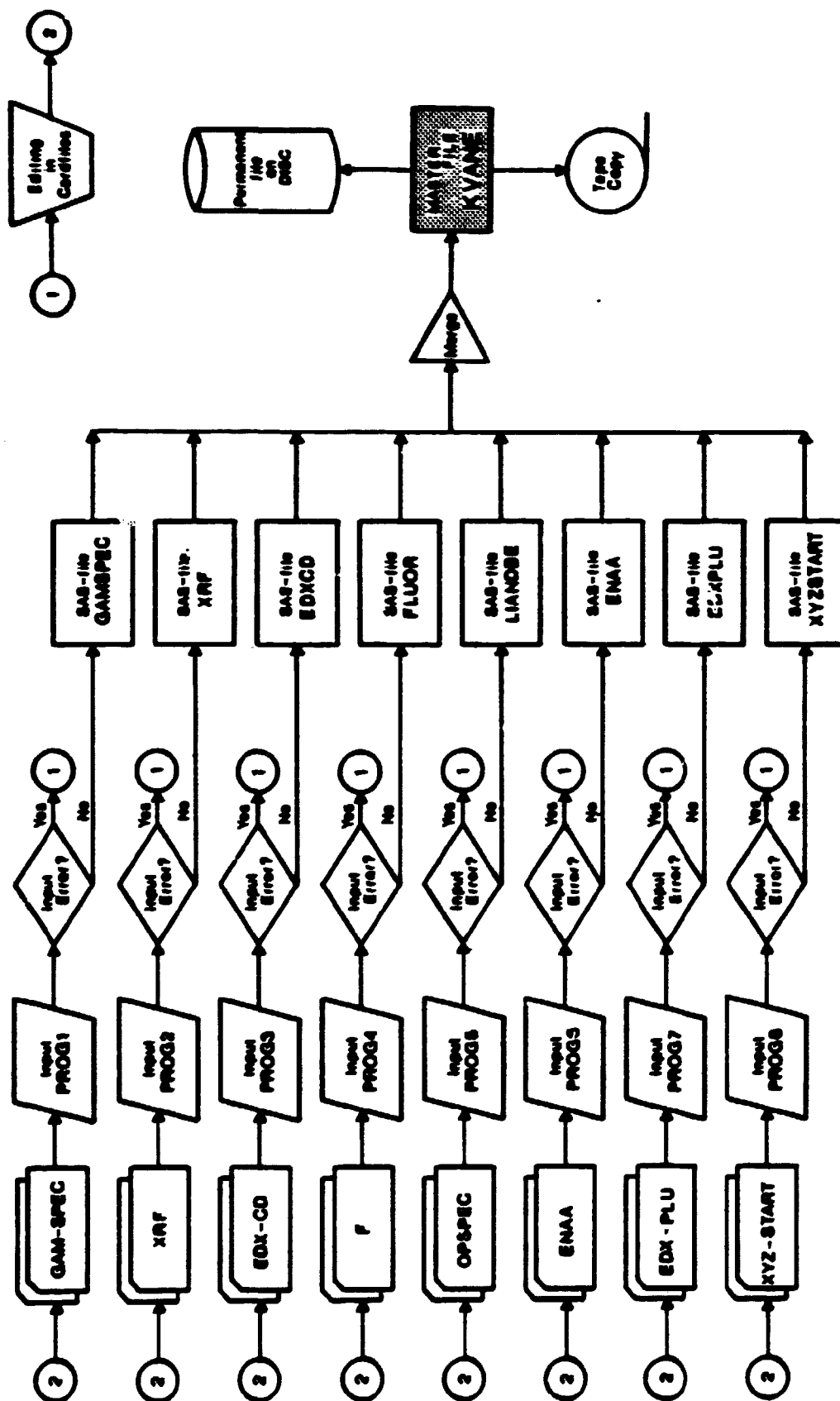


Figure 3. Flow chart showing the main programming phases in the creation of the database KVANZ.

two or more data cards contained one observation. When errors were found editing was made directly on the card file.

A self explanatory way of naming analytical variables was chosen. An analytical variable name has the following structure in KVANE

EL_UNIn,

where EL is the element symbol, UNI the value unit (either PPM or PCT) and n the method index (see table 1). A variable representing an ENAA value of La given in ppm will accordingly be named LA_PPM6. In this way a discrimination between the same elements obtained from different analytical methods is possible.

In connection with the creation of the sub data sets of GAM-SPEC and XYZ-START (fig. 3) a number of geometric quantities was calculated. Since geostatistics deals with spatial distributed samples (Matheron, 1963), X, Y and Z coordinates were calculated according to a local X,Y coordinatesystem (fig. 4). The Z coordinate is simply the altitude of the sample above sea level. To get a proper X,Y system transformed coordinates were calculated by:

$$XTR = 1100 - X$$

$$YTR = Y + 1100$$

$$ZTR = Z$$

Among the rest of the variables included in KVANE the DIP and AZIMUTH of the drill holes, distance from drill hole starting point to either sample top or sample bottom and a three digit geology code should be mentioned.

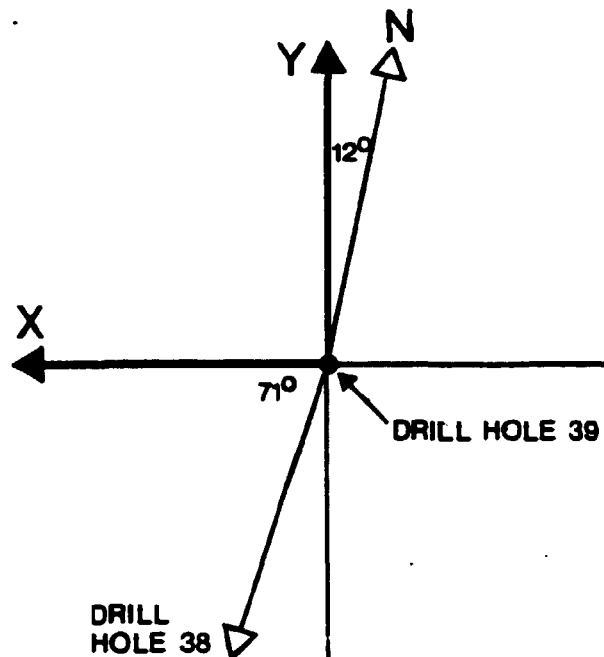


Figure 4. Orientation of the coordinate system in proportion to magnetic north and drill hole 39. (After Nyegaard et al., 1977).

HOW TO USE THE DATABASE KVANE

As shown in figure 3 the master file KVANE is stored both on a permanent disk and on magnetic tape (two copies). In periods where KVANE is not used, the disk file is deleted in order to save space for other purposes, but is easily recreated by copying back from one of the tape copies. Unfortunately this copying is necessary since SAS is unable to read directly in a SAS data set stored on magnetic tape.

All work with KVANE can as previously mentioned take place either interactively or in batch jobs. The way of operating is similar in the two cases. The interactive SAS is quite time-sharing and therefore more expensive than batch jobs. The latter are considered to be more safe.

When working with KVANE a temporary working data set which is an exact copy of KVANE is created. This is done by the DATA/SET command. The principle is then to reduce this working data set to contain the data of interest by deleting observation and variables. This procedure is explained in the following two examples. Comment-statements are indicated with a '*' in column one and all statements are separated by a semicolon.

Example one.

Suppose a listing is required in a file A containing the ENAA analyses for Fe, Co and Zn from drill core 59. Missing values should be excluded, and the listing should be in a specified format. The file A could either be on disc, card puncher or on line printer. Finally simple statistics such as the mean and variance are to be calculated.

```
1: * WORKING DATA SET IS CREATED FROM KVANE;
2:   DATA KVWORK 1; SET KVANE;
3: * DRILL CORE 59 IS SELECTED;
4:   IF BH=59;
5: * THE DATA OF INTEREST ARE SELECTED;
6:   KEEP PR_NR FE_PPM6 CO_PPM6 ZN_PPM6;
7: * OBSERVATIONS WITH MISSING VALUES ARE DELETED;
8:   IF FE_PPM6 =. AND CO_PPM6 =. AND ZN_PPM6=.;
9: * THE CONTENT OF KVWORK1 IS WRITTEN ON TO FILE A
10: * (HERE THE LINE PRINTER) IN A SPECIFIED FORMAT;
11:   FILE PRINT;
12:   PUT (PR_NR FE_PPM6 CO_PPM6 ZN_PPM6) (8.2 3*13.3);
13: * CALCULATE SIMPLE STATISTICS;
14: * THE WORKING DATA SET IS REPRODUCED FIRST;
15:   DATA STAT, SET KVWORK;
16:   PROC MEANS, N MEAN STD VAR;
```

Example 2

If we want to sort data according to topography, say, we want to find the data points in a 100x100x50 meter large block with the lower left corner placed in (XTR,YTR,ZTR)=(500.0,700.0, 500.0). Besides the coordinates of the data points found in the block, we need the sample number, the drill core number, the geology code (GEOLOGY) and the uranium- and thorium values determined by gamma-ray spectrometry. Output should be printed by descending ZTR value on a line printer disregarding formats. Using the same notation as in example one we get:

```
1: * WORKING DATA SET IS CREATED;
2:  DATA KVWORK2; SET KVANE;
3: * SELECT DATA POINTS ACCORDING TO TOPOGRAPHY;
4:  IF XTR >=500.0 AND XTR <=600.0;
5:  IF YTR >=700.0 AND YTR <=800.0;
6:  IF ZTR >=500.0 AND ZTR <=550.0;
7: * SELECTING THE VARIABLES NEEDED;
8:  KEEP PR_NR BH GEOLOGY XTR YTR ZTR U_PPM1 TH_PPM1;
9: * SORT THE DATA POINTS FOUND;
10: PROC SORT, BY DESCENDING ZTR;
11: * PRINT OUT THE RESULT;
12: PROC PRINT, BY BH;
```

UPDATING KVANE

New observations (analytical data on new samples) and variables (e.g. further elements) can easily be added to the KVANE database. This is done by UPDATE and MERGE commands. A SAS data set containing the new data material is created and then merged together with KVANE using either a BY variable (here PR_NR) or variable names already contained in KVANE. Since the permanent SAS data set contains a directory with variable names, SAS itself

ensures that the additional data go into the correct rows and columns. The updating procedure could also be used for replacing missing values in KVANE with real values.

Editing in the existing KVANE database is done using the EDITOR procedure.

DISCUSSIONS AND CONCLUSION

It was found that the SAS system was suitable for creating a database with drill core information from Kvanefjeld. Working with KVANE and other similar databases created by using SAS has shown, that the system is easy to operate even for users with minimum of ADP knowledge.

The greatest disadvantage by using SAS in the present case is the system dependency. KVANE has to be operated on a computer with SAS facility available. However, the user could transfer a limited number of data as formatted records (e.g. card images) to another computer without SAS, but should be aware of the space expansion. It should also be mentioned that storing data as a SAS data set requires more file space than necessary since space is reserved for missing values. On the other hand, the file space is small compared with data kept as card images.

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DANSK RESUME

I et forsøg på at samle alle borekerneinformationer hidrørende fra boreprogrammer udført på uranforekomsterne ved Kvanefjeldet i Sydvestgrønland, er en database betegnet som KVANE blevet udviklet. Til formålet benyttedes et anvendelsesprogrammel "Statistical Analysis System" (SAS), som sædvanligvis benyttes til statistiske programmeringsopgaver. Arbejdet har vist, at SAS, der arbejder uafhængigt af andre EDB-programmeller, er et udmærket stykke værktøj, når større datamængder skal lagres binært. Det er også vist, at adgangen til disse kan foregå uden større EDB-kendskab.

Artiklen giver en kort introduktion til SAS-systemet og beskriver dernæst, hvorledes KVANE er opbygget. Ved hjælp af to mindre programeksempler vises hvorledes specifikke data let udtages fra databasen, sorteres og overføres til yderligere behandling.

KVANE, der er implementeret på NEUCC, Danmarks tekniske Højskole, er systemafhængig og kan derfor ikke uden videre kopieres til et andet regneanlæg, med mindre dette besidder en SAS-facilitet.

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